

DOCUMENT RESUME

06798 - [B2287352]

Questionable Suitability of Certain Salt Caverns and Mines for the Strategic Petroleum Reserve. EHD-78-65; B-178205. August 14, 1978. 24 pp. + appendix (13 pp.).

Report to the Congress; by Robert P. Keller, Acting Comptroller General.

Issue Area: Energy: Role of Fossil Fuels in Meeting Future Needs (1509).

Contact: Energy and Minerals Div.

Budget Function: Natural Resources, Environment, and Energy: Energy (305).

Organization Concerned: Department of Energy.

Congressional Relevance: House Committee on Science and Technology; Senate Committee on Energy and Natural Resources; Congress.

Authority: Energy Policy and Conservation Act (P.L. 94-163). Federal Mine Safety and Health Act of 1977 (P.L. 95-164).

The Energy Policy and Conservation Act requires the Department of Energy (DOE) to create a strategic petroleum reserve to protect against disruptions in energy supplies. DOE plans to store 1 billion barrels of crude oil in salt caverns and mines by December 1985. Although the Department has not yet estimated the cost to store 1 billion barrels, it did estimate the cost to store 750 million barrels at \$14.4 billion.

Findings/Conclusions: Of the 19 existing salt caverns that DOE has acquired, 6 may not be suitable for long-term storage because they do not meet structural design standards for oil storage suitability. Three of the six caverns have already been certified for storage, but the other three failed to pass tests. Alternatives to the continued use of these caverns if they are found to be unsuitable are: (1) abandoning the unsuitable caverns and using additional cavern storage capacity developed during withdrawal, or (2) using salt water to displace oil during withdrawal so no additional growth can take place. If these alternatives do not work, DOE may have to resort to acquiring other existing caverns or building new ones. The salt mine acquired by DOE may not be suitable for long-term crude oil storage because of safety problems and the resulting potential legal and financial ramifications. Cost estimates for acquisition, construction, and operation of reserve storage facilities have not been adequately documented.

Recommendations: The Secretary of Energy should: study the alternatives for minimizing the risks associated with using the potentially unsuitable caverns and make the study results available to the Congress; develop a formal system for documenting, before test completion, any acceptable deviations and approvals for such deviations; delay further oil storage development at the salt mine until a solution has been developed to the problems involved in using the salt mine for storage; and

insure that all further cost estimates relating to the reserve program are adequately documented. (BRS)

7352

BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

Questionable Suitability Of Certain Salt Caverns And Mines For The Strategic Petroleum Reserve

The Department of Energy is creating a petroleum reserve to protect against future disruptions in U.S. energy supplies. The Department is committed to storing 500 million barrels by 1980 and 1 billion barrels by 1985. The crude oil will be stored underground in salt caverns and mines. Thus far, three salt cavern sites and one salt mine have been acquired to store this oil.

Tight time constraints coupled with the complex and technical nature of the program have resulted in the Department taking actions without adequate analysis to assure that risks are minimized. For example, the Department is planning to store oil above where mining operations are scheduled to begin in 1980 even though the Federal agency responsible for miner safety has said that serious or disastrous safety hazards to the miners and the oil storage area could result.



EMD-78-65
AUGUST 14, 1978



COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-178205

To the President of the Senate and the
Speaker of the House of Representatives

This report discusses actions taken by the Department of Energy without adequate analysis to assure that risks of using certain salt caverns and mines for the strategic petroleum reserve are minimized. The authorization of this reserve is the major action which has been legislated so far to lessen U.S. dependence on imported oil. This report is intended to make the Congress aware of the possible ramifications of risks being taken by the Department in implementing the reserve program, as well as alternatives available to minimize these risks.

We made our review pursuant to the Budget and Accounting Act of 1921 (31 U.S.C. 53), and the Accounting and Auditing Act of 1950 (31 U.S.C. 67).

We are sending copies of this report to the Director, Office of Management and Budget; the Secretaries of Energy and Labor; interested congressional committees; and other interested parties.

A handwritten signature in black ink, appearing to read "R. F. Kistler".

Acting Comptroller General
of the United States

D I G E S T

In December 1976, the Department of Energy submitted a plan to the Congress for 150 million barrels of reserve oil by December 1978 and 500 million barrels by 1982. Five months later, the Department accelerated the reserve targets to 250 million barrels by December 1978 and 500 million barrels by December 1980; currently, the Department plans to store 1 billion barrels by December 1985. The rationale for the acceleration was to provide the United States with increased petroleum supply protection as soon as practicable. The Department has revised its plans again and now expects to reach its 250 million barrel target by June or July of 1979.

To reach these goals, the Department decided to concentrate initially on converting existing salt caverns and mines into storage areas, rather than constructing new caverns or mines. As of mid-June 1978, the Department had acquired four sites containing 19 salt caverns and one salt mine to be used for storing oil. (See p. 1.)

While the Department has not yet estimated the cost to store 1 billion barrels, it did estimate the cost to store 750 million barrels at \$14.4 billion. (See p. 1.)

Storage targets for the reserve appear very ambitious, in view of the complex and technical nature of the program, and have had a dominant influence on Department actions and decisions. It is GAO's view that the Department has not allowed sufficient time to consider adequately the pros and cons of many of the decisions that have been and must be made to develop the reserve. Consequently,

the tight time constraints for the reserve program, coupled with the fact that the program is new and complex, surround certain elements of the program with a degree of risk that may be unacceptably high. (See p. 17.)

POTENTIAL PROBLEMS OF
USING CERTAIN SALT
CAVERNS FOR STORAGE

Of the 19 existing caverns the Department has acquired, 6 may not be suitable for long-term storage because they do not meet structural design standards for oil storage suitability and may grow together. Three of the six caverns already have been certified for storage. The other three have failed to pass tests. The Department has deferred a decision on whether to try to certify these three caverns until further study of the salt dome has been completed. (See p. 6.)

The Department has mentioned two alternatives to continued use of these caverns if they are found to be unsuitable.

1. Abandon the unsuitable caverns and use additional cavern storage capacity that had been developed during withdrawal.
2. Use salt water to displace oil in the caverns during withdrawal so no additional growth could take place and the potentially unsuitable caverns would not grow together.

However, if these alternatives are unworkable, the Department may have to resort to acquiring other existing caverns or mines, or constructing new ones. Because of the significant problems that these six caverns could pose (loss of oil, program delays, and additional cost) GAO believes the Department should not proceed before alternative courses are examined. (See p. 7.)

PROBLEMS AT THE ACQUIRED MINE

The salt mine that the Department has acquired may not be a suitable or practical facility for long-term crude oil storage because of problems disclosed by the Mining Safety and Health Administration, and because of the resulting potential legal and financial ramifications. Additional problems are:

- The Department's test program for determining the mine's suitability may not have been adequate, and interpretation of test results may be questionable. (See p. 8.)
- If Morton Salt Company mines salt 300 to 370 feet under the storage area, as planned, miners' safety and the integrity of the oil storage could be in jeopardy. (See p. 10.)
- If Morton Salt Company is prevented from mining as planned, adverse financial impact to Morton and nearby communities is possible and could result in legal action against the Department. (See p. 11.)
- A potential water problem exists which could result in oil washing out of the storage area damaging the environment. (See p. 12.)

These problems give rise to two basic questions: (1) is the mine structurally suitable for crude oil storage and (2) if so, is it cost effective in view of the additional expense that could be incurred to insure miner safety and integrity of oil storage? The resolution should consider minimizing adverse economic and social impact on all affected parties. The Department has agreed to enter into a memorandum of understanding with the Mining Safety and Health Administration to improve cooperation and develop a program that is in the best interest of the Government. (See p. 19.)

NO DOCUMENTATION REGARDING
DEVIATIONS FROM CAVERN TEST
CRITERIA

Before the Department uses caverns to store oil, it has them tested by a contractor. The test program calls for a test at pressures higher than are expected to be experienced when crude oil is pumped in and out of the caverns. GAO found that two caverns were not tested to these pressure levels. Because the deviations were small, this may not, in and of itself, be a serious problem. However, the Department does not have a formal system to document allowable deviations from specified testing criteria. This could lead to unauthorized deviations or tendencies to approve unacceptable deviations from the test program. (See p. 5.)

ADEQUACY OF STORAGE FACILITY
COST ESTIMATES

Accurate cost information is essential to appropriations committees when considering requests for program funds. This is particularly true with extremely high cost programs such as the strategic petroleum reserve. The cost estimates for acquisition, construction, and operation of reserve storage facilities were not adequately documented; however, the Department has taken steps to improve the adequacy. (See p. 15.)

RECOMMENDATIONS TO THE
SECRETARY OF ENERGY

The Secretary, Department of Energy, should make every attempt to minimize risk, uncertainty, and when practicable, program costs to insure that oil is stored in suitable, stable storage facilities until needed.

Specifically, GAO recommends that the Secretary

--study the alternatives for minimizing the risk associated with using the potentially

unsuitable caverns acquired for storage, making the study results available to the Congress;

- develop a formal system for documenting, before test completion, any acceptable deviations from pressure levels specified in the test program, and approvals for such deviations;
- delay further oil storage development at the salt mine until (1) the Mining Safety and Health Administration and the Department have jointly studied what additional testing is needed to insure that the salt mine is suitable for long-term crude oil storage and (2) the Department and the Mining Safety and Health Administration have worked together to develop a solution to the problems involved in using the salt mine for storage; and
- insure that all future cost estimates relating to the reserve program are adequately documented.

COMMENTS ON DRAFT REPORT

The Mining Safety and Health Administration sent GAO a copy of an April 24, 1978, memorandum to the Secretary of Labor stating that Department " * * * planning for the active mining and oil storage within the same dome has the potential for serious to disastrous health and safety hazards to the miners"; and, the Department "continuing its present program in the manner planned would be an embarrassment to the Government." (See p. 20.)

The Morton Salt Company questioned certain facts and statements in GAO's report, including statements that the Mining Safety and Health Administration had concerns about safety aspects of concurrent mining and oil storage at the mine. (See p. 20.)

The Department of Energy addressed two general areas. First, it believes that GAO's concern over the potential for caverns growing together is unwarranted. However, the Department admitted that the possibility of caverns growing together after multiple withdrawals is real. Further, it said that it will develop plans for refill of the reserve which will include abandoning or modifying the use of certain caverns, if necessary. (See p. 22.)

GAO agrees that it is desirable to develop such plans. However, they should be based on a thorough study, including the costs and benefits, of alternatives to both (1) continued use of caverns which could grow together and (2) using altogether different storage facilities. (See p. 22.)

The second area was the safety of using the salt mine for oil storage. The Department said that there is no evidence, facts, or test data to indicate that the mine is not suitable for oil storage. It also said that there was no reason to delay storing oil at the site and that the planned mining operations, which could involve safety hazards, are not scheduled to begin until 1980. The Department believes that any necessary corrective actions can be taken before then. (See p. 22.)

Because concerns raised by the Mining Safety and Health Administration have serious potential consequences, delay of further oil storage development at the mine, in GAO's opinion, is warranted until these concerns are put to rest. (See p. 19.)

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ABBREVIATIONS

DOE	Department of Energy
EPA	Environmental Protection Agency
GAO	General Accounting Office
MSHA	Mining Safety and Health Administration

CHAPTER 1

INTRODUCTION

The Energy Policy and Conservation Act (Public Law 94-163) requires the Department of Energy (DOE) ^{1/} to create a strategic petroleum reserve (reserve) to diminish U.S. vulnerability to the effects of a severe interruption in energy supplies and to provide limited protection from the consequences of interruptions in petroleum product supplies. In December 1976 DOE submitted to the Congress a strategic petroleum reserve plan (plan) which stated that the reserve would contain 150 million barrels of oil by December 1978, and 500 million barrels by December 1982.

In his April 1977 energy message, however, the President called for expanding the program to 1 billion barrels. Subsequently, DOE's May 1977 plan amendment set new reserve targets of 250 million barrels by December 1978, and 500 million barrels by December 1980; however, DOE does not expect to store the first 250 million barrels until mid-1979. DOE expects to store 1 billion barrels by December 1985. While DOE has not yet estimated the cost of storing 1 billion barrels, DOE's estimated cost for storing 750 million barrels is \$14.4 billion.

DOE determined that underground storage was the least costly, most feasible way to store large amounts of oil. Consequently, oil for the reserve will be stored in salt caverns and in mines. Nine potential storage sites with existing capacities totaling 391 million barrels were initially identified. DOE, as of mid-June 1978, had acquired four of these sites through condemnation proceedings--three salt cavern sites and one salt mine. The acquired sites are in Texas and Louisiana near the Gulf coast.

CRUDE OIL STORAGE IN SALT CAVERNS

In the United States, salt caverns have been used for over 20 years to store petroleum products including fuel oil

^{1/}Many of the statements and actions attributed to DOE in this report were actually stated and performed by the Federal Energy Administration. For simplicity, however, DOE is referred to throughout the report. The functions of the Federal Energy Administration were transferred on October 1, 1977, to DOE.

and natural gas, but they have not been used to store crude oil. In France and West Germany, however, crude oil has been stored in salt caverns for several years.

Salt caverns are created by a fairly simple process called leaching or solution-mining. First, a well is drilled into the salt formation. The well is lined with steel casing which is set in cement to seal off freshwater beds and other formations. Freshwater or sea water is then pumped down a tube within the casing to dissolve the salt.

After leaching, the cavern contains a salt-water substance called brine. Crude oil can then be pumped down between the tubing and the casing to force the brine up through the tube. The oil floats on the remaining brine. Crude oil is withdrawn from a cavern by reversing the fill process. By pumping water down the tubing the crude oil is forced up between the tubing and the casing. The chart on page 3 shows the operation of a crude oil storage cavern.

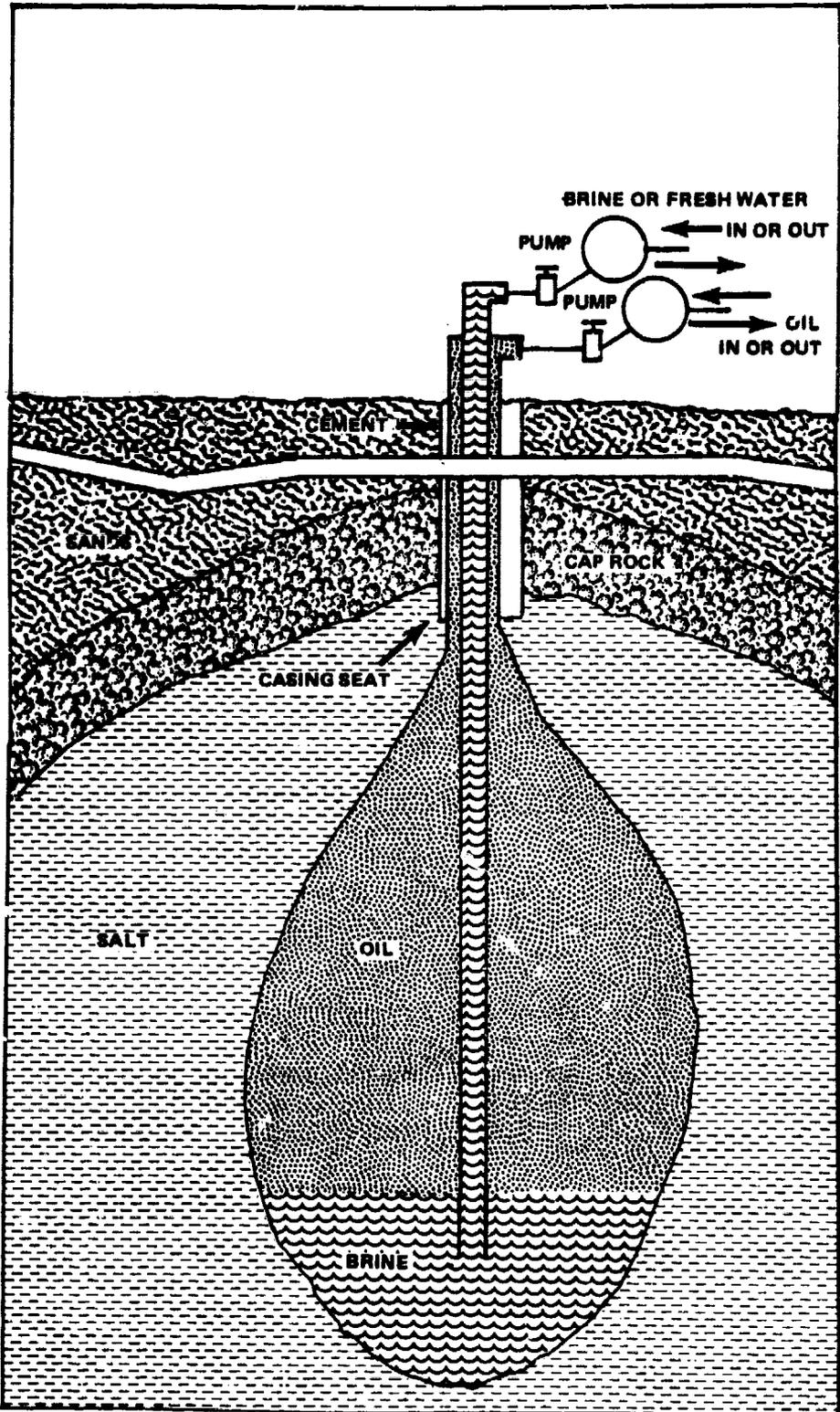
CRUDE OIL STORAGE IN CONVENTIONAL MINES

Although no crude oil is stored in mines in the United States, it has been stored in an iron mine in France, a potassium mine in West Germany, and a coal mine in South Africa. The process of converting a mine for crude oil storage involves removing the oil production and shaft equipment, preparing the mine floor by installing a sump pump, grading the floor to insure drainage to the pump, and installing casing for oil fill and withdrawal. Unlike the salt caverns where water is used to displace crude oil, submersible pumps are used to withdraw oil from mines.

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Potential problems relative to salt caverns and salt mines planned for storage are discussed in this report as well as the effects of long-term storage on the physical and chemical properties of crude oil, the potential for crude oil losses, and the estimated costs of the storage facilities.

OIL STORAGE OPERATION IN A SALT DOME



CHAPTER 2

POTENTIAL PROBLEMS RELATIVE

TO SALT CAVERN STORAGE

To attain its goal of 250 million barrels of oil in storage by December 1978, DOE decided to concentrate initially on converting existing salt caverns and mines into storage areas rather than constructing storage areas, which would take more time. Consequently, DOE acquired the following four sites that have existing caverns and a salt mine. These have a combined capacity of about 261 million barrels.

<u>Site</u>	<u>Location (Parish/County and State)</u>	<u>Type of underground storage</u>	<u>Estimated existing capacity in barrels (millions)</u>
Bayou Choctaw	Iberville, La.	Salt caverns	<u>a/74</u>
Bryan Mound	Brazoria, Tx.	Salt caverns	62
West Hackberry	Cameron, La.	Salt caverns	50
Weeks Island	New Iberia, La.	Salt mine	<u>75</u>
Total			<u>261</u>

a/Plans to use 30 million of the 74 million barrels of capacity have been deferred until a study of the salt dome is completed.

DOE acquired a total of 19 salt caverns at Bayou Choctaw, West Hackberry, and Bryan Mound to use for crude oil storage. The caverns had been solution-mined over a period of years by chemical companies to obtain brine feedstock for their manufacturing processes. These caverns were not designed to store crude oil.

DOE hired a contractor to test the suitability of these caverns for storing oil. The contractor determines, through testing, if a cavern is suitable for crude oil storage. If the cavern is found suitable, the contractor certifies that the cavern is structurally sound for oil storage. As of April 7, 1978, the contractor had certified 11 caverns.

We found, however, that the contractor made certain small deviations from the testing program. More importantly, we are

concerned that of the 19 salt caverns, 6 may not be suitable for long-term storage because they do not meet design standards for oil storage suitability preferred by companies who design, construct, and operate storage caverns. These six caverns have about a 55-million-barrel capacity worth about \$669 million in oil. Three of these six caverns have already been certified and are to be used for storage. The other three caverns have failed to pass the tests for storage suitability.

NO DOCUMENTATION REGARDING DEVIATIONS FROM CAVERN TEST CRITERIA

The testing program calls for the caverns to be tested to measure resistance to fracturing at pressures which will be experienced when crude oil is pumped in and out of the caverns. To allow for a safety margin, the test program requires that caverns be tested at pressures higher than the planned operating pressures. We reviewed the contractor's cavern certification files to determine if tests were conducted in accordance with pressure criteria specified in the test program. Two caverns at West Hackberry--caverns number 6 and 9--were tested at pressures slightly below those specified in the cavern test program. For cavern 6 the test program called for 732 pounds of pressure, but the cavern was tested to 710 pounds of pressure. For cavern 9 the test program required 650 pounds of pressure, but the cavern was tested to 640. These test pressures are 30 percent above the maximum planned operating pressure of the caverns according to DOE officials. According to the testing contractor, these deviations were acceptable because cavern testing is time consuming, and the additional time required to reach the specified pressure did not justify achieving the small increase in the safety factor. One DOE official told us that he had given verbal approval to the contractor to make the deviations. However, he said this approval had not been documented.

Another DOE official stated that DOE relies on the expertise and experience of the testing contractor for acceptable deviations from the testing program. Whenever the contractor believes the cavern is suitable after performing the tests --even with deviations--the contractor certifies the cavern. The official added, however, that after reviewing the certification document and the testing data on which the certification was based, DOE has the option of not accepting the certification. DOE did not exercise this option and accepted certifications on the two caverns which were tested at lower pressures than those specified in the test program.

POTENTIAL PROBLEM OF CAVERNS GROWING TOGETHER

The reserve is being designed to accommodate up to five fill and withdrawal cycles. DOE assumes that oil may have to be pumped into and out of storage five times during the life of the reserve. According to a DOE report, each such cycle can cause caverns to expand an estimated 14 percent. This expansion could change the configuration of the caverns, including height to diameter ratios. Most importantly, it could cause caverns to grow together, forming new caverns with completely different shapes and height to diameter ratios.

The relationship of cavern height to cavern diameter and the distance between caverns are important considerations when determining salt cavern structural stability and suitability for crude oil storage. These factors can indicate potential massive fracturing of the cavern walls or total collapse of the ceilings.

We attempted to identify specific criteria for cavern height to diameter ratios and minimum distance between caverns. We found, however, through discussions with officials representing firms experienced in designing, constructing, and operating storage caverns that specific criteria do not exist. We did find, however, that each company has preferred design standards, ranging from 3:1 to 10:1 for height to diameter ratios and from 270 to 575 feet for minimum distance between caverns. Moreover, a DOE contractor responsible for designing and constructing new caverns for the reserve is planning on a height to diameter ratio of 9:1 and a minimum distance between caverns of 520 feet.

Six caverns acquired for storage do not conform to these preferred design standards--caverns number 6 and 9 at West Hackberry and caverns 3, 11, 13, and 15 at Bayou Choctaw. For each of the six caverns, the distance from one or more other caverns is substantially less than the minimum preferred distance of 270 feet. Four of the caverns have a height to diameter ratio of less than the minimum preferred ratio of 3:1--ranging from 2:1 to 1:5. Of the six caverns, three already have been certified suitable for crude oil storage. Caverns 3, 11, and 13 at Bayou Choctaw failed to pass pressure tests.

We discussed this issue with DOE officials. They told us that three of the caverns--caverns 3, 11, and 13 at Bayou Choctaw--have already grown together and a decision on whether to use them has been deferred until further study of the salt dome has been completed. These officials also said that while they recognize that the potential exists for the remaining

three caverns to grow together, they are still planning to use these caverns for storage.

DOE officials also told us that all caverns would be retested after each fill and withdrawal cycle to determine if the caverns remain structurally stable or suitable for oil storage. If caverns did not remain suitable, DOE said it could either (1) abandon the unsuitable caverns and use additional cavern storage capacity that would be developed during a withdrawal cycle or (2) use brine as a displacement fluid so that no additional growth could take place. In our view, unanswered questions remain as to the viability of these options. Regarding the first option, reserve plans call for refilling caverns only to their initial capacity so that cavern enlargement could be minimized and so that adequate withdrawal rates can be maintained. Regarding the second option, DOE is aware that using brine would be very expensive and that there could be environmental problems associated with its use. In summation, although DOE has pointed to these options as solutions, the questions that face the use of these options have not been answered.

CHAPTER 3

QUESTIONABLE SUITABILITY OF A SALT

MINE PLANNED FOR CRUDE OIL STORAGE

Weeks Island Salt Mine, a storage site for the reserve program, has operated since 1902 and is now operated by Morton Salt Company. The mine consists of two levels; but the upper level has been abandoned since 1956 when production started on the lower level. DOE intends to store about 75 million barrels of oil in both levels, beginning in January 1979.

DOE acquired a minimum amount of the salt dome at Weeks Island so that mining activities there could continue and any adverse economic impacts on Morton and nearby communities could be minimized. Morton is now developing a temporary mining level beside the oil storage area, and Morton officials stated that they will begin mining between 300 and 370 feet directly below the oil storage area in 1980.

We looked into three aspects of the decision to store oil at this site: (1) the adequacy of DOE's program to test the existing mine for its suitability as a storage site, (2) the effects of mining below the oil storage area, and (3) a potential water problem at Weeks Island.

DOE'S MINE TESTING PROGRAM MAY NOT BE ADEQUATE

DOE selected the same contractor that is testing and certifying salt caverns to test the mine's storage suitability. The contractor developed a mine testing program for DOE and subcontracted with a mining engineering and consulting firm to carry out the tests. On January 17, 1978, the contractor certified Weeks Island Salt Mine as suitable for crude oil storage.

Because of concern for the health and safety of the salt miners who could be working below the oil storage area, the Department of Labor's Mining Safety and Health Administration

(MSHA) 1/ reviewed the DOE testing program that had been used as the basis for certifying the mine's suitability for storing oil. MSHA officials found that DOE's mine testing program was not adequate. Based on the number and type of salt samples tested, MSHA officials questioned how a reliable determination could be made that the mine is structurally suitable for oil storage. The salt samples that were taken, according to MSHA officials, are not representative of all conditions in the mine and the test results just as easily could have been interpreted that the mine is not suitable for oil storage.

Further, DOE tested only the lower level of the mine. But, MSHA believes that the upper level should also be tested because salt characteristics can change on a vertical plane. According to MSHA officials, because of the magnitude and cost of the reserve program, DOE is taking an unacceptably high risk in assuming that the salt characteristics in the upper level can be accurately projected based on data obtained from testing the lower level. DOE officials disagreed. They said that testing the upper level was not necessary because on a vertical plane, there are no significant changes in salt characteristics. They stated that any changes that do exist are a function of depth and, thus, can be calculated. DOE's conclusion, therefore, was that the lower level test generated data that could be extrapolated reliably to the upper level. Furthermore, DOE officials told us MSHA had refused to permit DOE to test the upper level.

We asked MSHA officials if they had refused to allow DOE to test in the upper level. MSHA officials stated that MSHA informed DOE officials that because the upper level is an abandoned mine, MSHA regulations require DOE to outline safety procedures for MSHA approval before DOE could enter the mine. DOE neither submitted the safety procedures nor again asked about testing the upper level, according to MSHA officials.

1/MSHA administers the enforcement provisions of the public laws and related standards and training programs to guard the health and safety of miners. MSHA was established March 9, 1978, and assumed the responsibilities of the Mining Enforcement and Safety Administration of the Department of the Interior.

UNCERTAIN EFFECTS OF CONTINUED MINING
BELOW THE OIL STORAGE AREA

A safe distance between the oil storage area and the new mining area is vital because of the potential for blowouts. Blowouts cause more salt than planned to be broken by blasting, resulting in rounded openings of various depths in the mine walls or ceilings. If Morton mines below the oil storage area, a blowout could occur in Morton's working mine, possibly extending to the oil storage area above and flooding the working mine with oil.

DOE's subcontractor responsible for testing the mine issued a final report on Weeks Island which recommended, "Neglecting the possibility of blowouts, a minimum web [salt] thickness of 300 feet should be provided to ensure the safety of mining operations below the oil storage facility." The report strongly recommended that mining below stored oil not be initiated until high-potential blowout areas could be positively predicted. According to the report, the consequences of a major blowout in a mine below stored oil could be disastrous and the risk of such occurrences must be eliminated to ensure the safety of miners and the integrity of oil storage.

According to Morton officials, the largest blowout that ever occurred at Weeks Island extended about 30 feet. Thus, because there will be between 300 and 370 feet of salt between the floor of the lower storage area and the roof of the proposed new mine, DOE and Morton officials believe that mining below the oil storage area as planned should be safe. DOE added, however, that sufficient study had not been done to predict and control blowouts. DOE further stated that, while unlikely, if blowouts were to damage the oil storage area, Morton would be totally responsible. Morton officials argue that, as long as Morton is not negligent in its mining activities, DOE would be financially liable for damage to the storage area and the mine below. In the event of mishap, the issue of financial responsibility, including possible negligence, by DOE, Morton, or others, would ultimately be determined in the Courts.

MSHA is concerned about the potential effects of blowouts at Weeks Island. According to MSHA officials, even if small blowouts were to occur, cracks and fractures resulting from the blowout could extend to the oil storage area and oil could leak into the mine below. Blowouts have occurred in five of six Louisiana salt mines. MSHA recently reported the results of a limited study of blowouts; oil, gas, and water seepages; and existing mining conditions at Weeks Island and all other Louisiana salt domes in that area. With respect to the Weeks Island blowout problem, the MSHA report concluded that Weeks Island may be the most blowout-prone dome that was studied. The report also concluded that no practical means exist to assure that mining will not penetrate into a blowout-prone

zone and that potential hazards are too great to permit mining 370 feet below oil storage. According to the report, unless facts are provided that assure a lesser distance is adequate, mining should not occur less than 650 feet below the oil storage area.

MSHA, however, believes that development of blowout evasion tactics may be possible through a more comprehensive study of the five Louisiana mines. MSHA estimated this study would take 1 year and would cost \$300,000. DOE has offered to provide financial and other assistance so that MSHA can conduct the necessary studies.

DOE officials stated that DOE is fully committed to protecting the health and safety of miners at Weeks Island. According to DOE, storage of oil in the existing mine does not present any immediate hazards to miners or the oil storage area because Morton is currently working beside the storage area.

DOE officials state that they believe that the salt area it has acquired around the mine is adequate to protect the oil storage area and a future salt mine below. However, if MSHA determines that DOE's salt area acquisition is insufficient to protect miners and property, DOE will take all action necessary to insure site safety. This, according to DOE, would include acquisition of additional salt beneath the storage area either by purchase or by right of eminent domain.

Existing underground storage capacity in the Gulf coast is very limited, according to DOE; and there are no alternative sites to Weeks Island for 75 million barrels of oil storage in the 1978-1979 time frame. No cost assessment has been made for the possible acquisition of additional salt beneath the existing mine, but DOE is prepared to assume this financial burden to protect miners and the oil storage area.

If MSHA precludes Morton from mining at Weeks Island or forces Morton to mine at a deeper level than planned, Morton officials stated that they would initiate legal action against DOE for, in effect, taking more salt in the dome than originally agreed to and paid for.

According to MSHA, a situation similar to Weeks Island may exist at Cote Blanche, one of the five potential sites identified for oil storage that DOE has not yet acquired. The Cote Blanche mineowner is planning to mine above the proposed oil storage area, according to MSHA. MSHA anticipates that the owner may also decide to mine beneath the proposed oil storage area because 900 million tons of salt could be recovered from such mining activity. MSHA officials further state

that hazards to the health and safety of miners are a likely result of concurrent mining and oil storage at Cote Blanche.

POTENTIAL WATER PROBLEM AT WEEKS ISLAND

The MSHA report concluded that a water infiltration problem exists at Weeks Island. If this problem is not controlled, the oil storage area could be destroyed, according to MSHA, and oil could be washed out of the storage area and pose a threat to the environment. Morton, in developing its temporary mine beside the oil storage area, encountered water flows which totalled 50 gallons per hour, according to MSHA. After certain corrective actions were taken, flows are now reported to be 4 to 5 gallons per hour.

DOE officials concur that water can be a serious problem. DOE also recognizes that water can leach openings in the salt and that determining the exact location of ground water at the edges of salt masses can be difficult. According to DOE, the water Morton encountered in the salt structure has been linked to subsurface water outside the salt mine and water flows into the new mining area are being continuously monitored. DOE believes that techniques can be developed to avoid water inflows.

MSHA is concerned that, while water may be controlled at the new mine, it could change its path and enter the oil storage area. According to the MSHA report, a water leak into the Avery Island mine in Louisiana was plugged by cement. But, 6 months later the water rerouted itself into the mine 200 feet away. This rapid, unpredicted movement of water, according to MSHA, emphasized its concern about the water infiltration at Weeks Island.

CHAPTER 4

EFFECTS OF LONG-TERM STORAGE ON

CRUDE OIL AND POTENTIAL LOSSES

DOE plans to store 1 billion barrels of crude oil and possibly petroleum products in the reserve. Current planning provides for withdrawal of this oil only if there is a severe interruption in energy supplies. In this chapter we address (1) how long crude oil can be stored and still remain suitable for refining and (2) how much oil might be lost during storage.

EFFECTS OF LONG-TERM STORAGE ON THE PHYSICAL PROPERTIES OF CRUDE OIL

DOE and petroleum company officials stated that, although the length of time crude oil can be stored in salt caverns or mines and remain suitable for refining is unknown, they believe long-term storage should not have any detrimental effects on crude oil. U.S. petroleum industry researchers have developed information concerning the effects of salt cavern storage on hydrocarbon stability, but this information is generally based on storage periods of less than 1 year.

The West German government has had crude oil stored in salt caverns for over 8 years--the longest period of time crude oil has been stored in salt caverns. DOE expects to contract with the West German company that constructed and is operating these caverns to obtain detailed information on the stability of the stored crude oil. DOE plans to award the contract costing about \$250,000 in mid-1978. The work will take about 1 year to complete.

One DOE official stated that after the caverns have been filled a year or so, DOE plans to sample the oil in the caverns and to test periodically the chemical composition of the crude oil. This information will then be given to refiners to make the necessary preparations to maximize product efficiency during any supply interruptions.

POTENTIAL CRUDE LOSSES

We discussed the potential for crude oil losses in salt caverns with DOE officials and with companies having experience in design, construction, and operation of salt caverns for crude oil storage--American petroleum companies, a West German company, and the Louisiana Offshore Oil Port. We learned that there are generally three ways crude oil can be

lost during storage: (1) leakage through cracks in the cavern, (2) loss during oil withdrawal, and (3) suspension of oil in brine.

If caverns remain structurally stable and do not crack, crude oil should not leak out of the caverns. During our discussions with officials of the American petroleum companies, the West German company, and the Louisiana Offshore Oil Port, we were told that because salt is impervious to petroleum, crude oil should not be lost due to absorption.

In commenting on the environmental impact statement DOE prepared for one of the storage sites, Environmental Protection Agency (EPA) officials stated that when oil is removed from the storage caverns, some oil will adhere to the cavern walls and will subsequently be suspended in the brine. EPA further stated that when oil is pumped back into the caverns, the displaced brine will carry the oil with it. According to DOE, the maximum amount of crude oil mixing with the brine during crude oil displacement would be about 18 parts per million. Applying the 18 parts per million estimate to a 1 billion barrel reserve, DOE can expect to lose about 18,000 barrels of oil (.0018 percent) during withdrawal operations.

DOE also stated that some oil will be suspended in brine near the oil-brine interface and concluded that the amount of suspended crude oil, commonly known as an emulsion, cannot be predicted. The emulsion amount can be minimized, however, by insuring that the oil-brine interface is not withdrawn from the cavern. The contractor who performed the engineering feasibility studies on new caverns for DOE suggested that the emulsified interface could be held in the cavern until its volume warranted treatment. As part of the German contract concerning the effects of long-term storage, studies will be conducted to determine if (1) unacceptable oil emulsions will be encountered and (2) treatment facilities are necessary for breaking the emulsion and recovering the oil.

CHAPTER 5

ADEQUACY OF STORAGE FACILITIES COST ESTIMATES

In discharging its legislative and surveillance responsibilities, the Congress needs information to evaluate the progress of Federal agencies in accomplishing program objectives and to identify problems needing resolution. Adequate program cost information is particularly essential.

In the strategic petroleum reserve plan submitted to the Congress in December 1976, DOE estimated that the costs to acquire, construct, and operate oil storage facilities would be \$765.9 million. A May 1977 amendment projected these costs to be \$785.2 million. DOE officials stated that acquisition costs contained in the plan were based on Corps of Engineers studies and that construction and operation costs were based on estimates contained in contractor studies made to assist in DOE's storage site selection process.

We did not analyze the adequacy of the cost estimates contained in the Corps of Engineers and contractor studies. We tried, however, to match the amounts in the Corps of Engineers and contractor studies with the amounts contained in the plan and plan amendment. Except for a few instances, the amounts were not the same. We then tried to determine the reason for the differences. DOE officials advised us that, for the most part, the basis for these differences was not documented and that it would be extremely difficult, if not impossible, to construct such documentation. DOE officials explained that adjustments were being made very quickly to the amounts and that there was not enough time for documentation.

Lack of documentation aside, we asked DOE officials to explain these differences to us. They could not fully explain these differences, but they stated that adjustments were being made for such technical factors as alternative pipeline link-ups and dock facilities.

In a March 7, 1978, letter to the Controller, DOE, we asked for his views concerning the adequacy of reserve cost documentation as well as assistance in providing us this documentation. In a March 23, 1978, response, the Controller agreed that there are problems in tracing the cost estimates back to contractor estimates because the adjustments were not well documented. The Controller also agreed that it is important for the Congress to have adequate cost information and indicated that substantial DOE attention has been rendered to promote adequate cost estimates for new projects and effective project management control.

The Controller also pointed out that in December 1977, DOE completed a comprehensive review of the reserve program management, cost, and schedule. One of the resultant management decisions was that reliable cost estimates for construction and operation of the reserve facilities would be developed.

CHAPTER 6

CONCLUSIONS, OBSERVATIONS, RECOMMENDATIONS, AND COMMENTS ON DRAFT REPORT

In December 1976 DOE submitted a reserve plan to the Congress, stating that the reserve would contain 150 million barrels of oil by December 1978 and 500 million barrels by 1982. Five months later, DOE accelerated the reserve targets to 250 million barrels by December 1978 and 500 million barrels by December 1980; and, currently, DOE plans to store 1 billion barrels by December 1985. The rationale for the acceleration was to provide the United States with increased petroleum supply protection as soon as practicable. DOE has revised its plans again and now expects to reach its 250 million barrel target by June or July of 1979.

We agree with DOE that it is desirable to provide the United States with petroleum supply protection as soon as practicable. In this regard, we believe that it is most important for DOE to insure that the reserve can be relied on to provide protection from the consequences of interruptions in energy supplies. DOE must, therefore, assure that oil is stored in facilities that will remain suitable for storage until the oil is needed.

We believe DOE's reserve storage targets are very ambitious in view of the complex and technical nature of the program. We further believe that the targets have had a dominant influence on DOE actions and decisions. It is our view that DOE has not allowed sufficient time to consider the pros and cons of many of the decisions that have been and must be made in developing the reserve.

Consequently, the tight time constraints for the reserve program coupled with the fact that the program is new and complex surround certain elements of the program with a degree of risk that may be unacceptably high. In the following sections we describe actions that DOE should take to minimize the risk.

POTENTIAL PROBLEMS OF USING CERTAIN SALT CAVERNS FOR STORAGE

Of the 19 existing caverns DOE has acquired, 6 may not be suitable for long-term storage because they do not meet structural design standards for oil storage suitability. The caverns are essentially too close to each other. Crude oil fill and withdrawal cycles could cause the six caverns to grow out to other caverns, forming new caverns with different dimensions. Three of the six caverns already have been

certified for storage. The other three have failed to pass the tests for storage suitability. DOE has deferred a decision on whether to try to certify these three caverns until further study of the salt dome has been completed.

DOE has mentioned two alternatives to continued use of these caverns if they are found to be unsuitable to refill. DOE said it could abandon the unsuitable caverns and use additional cavern storage capacity that had been developed during a withdrawal cycle, or it would use brine as a displacement fluid so that no additional growth could take place. DOE has not fully studied these alternatives. It may be that these alternatives are unworkable. If so, DOE may have to resort to acquiring other existing caverns or mines, or constructing new caverns or mines. In view of the significant problems that these six caverns could pose (loss of oil, program delays, and additional costs) we believe it would be imprudent for DOE to proceed before alternative courses are examined.

NO DOCUMENTATION REGARDING DEVIATIONS FROM CAVERN TEST CRITERIA

The two caverns at the West Hackberry site were not tested to specified pressure levels in DOE's cavern test program. The deficiency may not be a serious problem, in itself, because the deviations were small. What may be serious is that DOE does not have a formal system for documenting allowable deviations from criteria specified in the test program before tests are completed. This could lead to unauthorized deviations or tendencies to approve unacceptable deviations from the test program, so time and money could be lost by re-testing caverns to acceptable pressure levels.

PROBLEMS AT THE WEEKS ISLAND MINE

We are concerned that the Weeks Island mine may not be a suitable or practical facility for long-term crude oil storage because of the problems surfaced by MSHA officials and because of the resulting potential legal and financial ramifications. The following problems are involved in using the Weeks Island mine to store oil.

- The DOE test program used to determine the mine's suitability may not have been adequate and interpretation of test results may be questionable.
- If Morton mines salt 300 to 370 feet under the storage area, as planned, miners' safety and the integrity of the oil storage could be in jeopardy.

--If MSHA precludes Morton from mining as planned, adverse financial impact to Morton and nearby communities is possible; furthermore, it could result in legal action against DOE.

--A potential water problem at Weeks Island could result in oil washing out of the storage area damaging the environment.

These problems can be focused into two basic questions: (1) is the mine structurally suitable for crude oil storage, and (2) if so, is it cost effective in view of the additional expense that could be incurred to ensure miner safety and integrity of oil storage? Because of the potential consequences we have mentioned, these questions must be answered. In so doing, we believe that DOE must work with MSHA to develop a strategy whereby the interests and concerns of all affected parties--especially miner safety--are considered and placed in proper perspective. The resolution should give due consideration to minimizing adverse economic and social impact on all affected parties.

MSHA and DOE officials met recently to discuss the problems that MSHA believes exist at the Weeks Island mine. At the time of our report, the two agencies had not reached agreement on the problems nor on a strategy for resolving them. DOE has agreed to enter into a memorandum of understanding with MSHA to improve cooperation and develop a program that is in the best interest of the Government. We believe that DOE and MSHA must resolve these problems before any additional work is done to convert the mine to an oil storage area.

ADEQUACY OF STORAGE FACILITY COST ESTIMATES

Accurate cost information is essential to appropriations committees when considering requests for program funds. This is particularly true with such extremely high cost programs as the strategic petroleum reserve. The cost estimates for acquisition, construction, and operation of reserve storage facilities were not adequately documented. DOE has taken steps which we heartily endorse, however, to improve the adequacy of cost estimates for the reserve.

RECOMMENDATIONS TO THE SECRETARY OF ENERGY

We recommend to the Secretary, Department of Energy, that every attempt be made to minimize risk, uncertainty, and program costs (when practicable), to insure that oil is stored in suitable, stable facilities until needed.

Specifically, we recommend that the Secretary

- study alternatives for minimizing the risk associated with using the potentially unsuitable caverns acquired for storage and make the study results available to the Congress;
- develop a formal system for documenting, before test completion, any acceptable deviations from pressure levels specified in the test program and approvals for such deviations;
- delay further oil storage development at Weeks Island until (1) MSHA and DOE have jointly studied what additional testing is needed to insure that the Weeks Island salt mine is suitable for long-term crude oil storage and (2) DOE and MSHA have worked together to develop a solution to the problems involved in using the Weeks Island mine for storage; and
- insure that all future cost estimates relating to the reserve program are adequately documented.

COMMENTS ON DRAFT REPORT

We sent a draft of this report to MSHA, DOE, and Morton for comment. Their comments are included as appendix I in this report.

MSHA comments

In responding to our report, MSHA sent us a copy of its March 1978 task force report on problems involved in using the Weeks Island mine for storage, and sent a memorandum dated April 24, 1978, transmitting the report to the Secretary of Labor. This memorandum reflects MSHA's concerns and states, "Present DOE planning for the active mining and oil storage within the same dome has the potential for serious to disastrous health and safety hazards to the miners." The memorandum also states that the MSHA Task Force, "in their report identifies the problem of uncontrolled flows of water, which even with the absence of active mining, has the potential for destroying the integrity of an oil storage area;" and, "DOE continuing its present program in the manner planned would be an embarrassment to the Government."

Morton comments

Morton responded to our draft report by giving some details on the history of the mine and how DOE acquired it. Morton's response stated that our report should recognize

that Morton's continued mining at Weeks Island minimizes the disruption not only to the Company and nearby communities, but also to the work force, to the local economy, including businesses and suppliers serving Weeks Island, to the up-river distribution system of Morton, and to the many hundreds of rock salt customers served by Weeks Island. We agree, as evidenced by our conclusions, that DOE and MSHA should develop a strategy whereby the interests and concerns of all affected parties are considered and placed in proper perspective and that due consideration should be given to minimizing adverse economic and social impact on all affected parties.

Also, Morton questioned certain facts and statements in the report, including our statements that MSHA had concerns about safety aspects of concurrent mining and oil storage at Weeks Island. However, MSHA's task force report clearly expresses serious safety concerns with the mine and describes the factual bases for these concerns.

Morton considers 300 to 370 feet of salt between the oil storage area and the proposed mine below to be very safe based upon standard operating practices and a rock mechanic's study. Morton also states that, to its knowledge, it is presumptive and conjectural to conclude that a blowout could occur in Morton's working mine that might extend to the oil storage area above and flood the working mine with oil. Morton also states that cracks and fractures extending from a blowout in the proposed mine would not extend vertically to the oil storage area. Morton further states that criteria are available for predicting areas with blowout potential, and Morton plans to take measures to avoid blowout-prone areas in future mining.

We are not convinced that a 300 to 370 foot distance between the oil storage area and the proposed new mine is safe and believe it has been clearly demonstrated that further study is needed before a safe distance, if any, can be positively predicted. To our knowledge, nowhere in the world has any mining activity taken place below underground oil storage; and, therefore, there is no standard operating practice for mining below stored oil. Furthermore, the rock mechanic's study addressed safe distance from the standpoint of the proposed salt thickness being able to withstand the stress of the stored oil, and did not address the effects of a blowout. MSHA officials stated that adequate criteria is not available to be able to predict and control blowouts and that cracks and fractures do extend vertically. Furthermore, according to MSHA, no practical means exists to assure that mining will not penetrate into a blowout-prone zone.

DOE comments

DOE's comments addressed two general areas. First, although DOE admitted that the possibility of caverns growing together after multiple withdrawals is real, DOE believes that our concern about the potential for caverns growing together is unwarranted. According to DOE, it will perform tests after each withdrawal to determine precisely the scope of cavern enlargement. DOE states that mitigating measures can be taken if these tests indicate that caverns could grow together after another fill and withdrawal cycle. Also, DOE intends to develop plans--to be furnished to the Congress--for abandoning or modifying the use of certain caverns if that should become necessary. We agree that it is desirable to develop such plans. However, such plans should be based on a thorough study, including the costs and benefits, of alternatives to both (1) continued use of caverns which could grow together and (2) using altogether different storage facilities. DOE has not fully studied these alternatives.

The second general area of DOE's comments was the desirability and safety of using the Weeks Island salt mine for oil storage. DOE does not agree that the mine may not be suitable for oil storage. DOE said that no evidence, facts, or test data exists to indicate that the Weeks Island mine is not suitable for oil storage.

In so doing, DOE disagreed with a study done by its own testing contractor, which stated that "all areas of the mine have different test results" and recommended that both levels of the mine be tested. However, DOE said that technical analyses performed by DOE contractors, which indicate that 300 feet of salt is desirable beneath the oil storage area, was based on, among other things, the potential for blowouts. This statement is inaccurate. A contractor's report DOE furnished to us to support this statement recommended, "Neglecting the possibility of blowouts, a minimum web [salt] thickness of 300 feet should be provided to ensure the safety of mining operations below the oil storage facility." (Under-scoring provided.)

DOE described several other factual differences it had with our report. These differences underscore the disagreement between MSHA and DOE over the suitability of the salt mine for oil storage and the need for these agencies to work together to resolve the serious problems that are involved.

Finally, DOE states that it disagrees that all uncertainties (no matter how minimal) should be or can be fully resolved before proceeding with implementation of the reserve program and further states that the risks are of little consequence

when compared with reduced protection which would result from delays in program development. While we agree that all uncertainties cannot be fully resolved, we do believe that the problems raised in this report are of significant concern to warrant that DOE take the corrective actions recommended. We further believe that delays are warranted to ensure that the reserve will be able to provide the degree of protection needed by the Nation to offset the impact of interruptions of oil imports.

CHAPTER 7

SCOPE OF REVIEW

We conducted our review at DOE offices in Washington, D.C. and Dallas, Texas; at the offices of the contractor responsible for testing and certifying storage caverns and mines; and at the Weeks Island, West Hackberry, and Bryan Mound storage sites.

We reviewed legislation, literature pertinent to underground storage, the storage site selection process, and cavern and mine test programs. We observed cavern and mine tests at three storage sites and interviewed DOE, MSHA, and contractor officials.

We also obtained comments regarding underground storage from

- two American petroleum companies which construct and operate underground storage caverns;
- a rock mechanics authority who is conducting research on the dimensions and stability of salt caverns;
- officials from Louisiana Offshore Oil Port--the deep-water port planned for construction in the Gulf of Mexico--which will use salt caverns for onshore facilities;
- Government officials associated with the Federal Republic of Germany's crude oil storage program; and
- a German company which constructs and operates salt caverns for oil storage.

U.S. DEPARTMENT OF LABOR
MINE SAFETY AND HEALTH ADMINISTRATION
4015 Wilson Boulevard
Arlington, Virginia 22203



JUL 07 1978

Mr. Gregory J. Ahart
Director, Human Resources Division
United States General Accounting Office
Washington, D.C. 20548

Dear Mr. Ahart:

The Mine Safety and Health Administration, Department of Labor, has completed their review of the drafts of a proposed report, "Questionable Suitability of Certain Salt Caverns and Mines for the Strategic Petroleum Reserve." Additionally, we have met with several members of your staff and discussed with them the first and second drafts of the report.

In March, the Five Island Salt Domes (LA) were investigated by members of the Mine Safety and Health Administration's Underground Storage Task Force and South Central District enforcement personnel to study the blowout phenomena, permeability and oil, gas, and water seepages, and to observe existing mining conditions. Their findings address some of the issues raised in your report. A copy of the Mine Safety and Health Administration Task Force Report is enclosed. The information contained in this report may be of assistance to you.

We have appreciated the opportunity to review your report and discuss with your staff its findings. If we can provide any further information, please do not hesitate to contact us.

Your interest in our mine safety and health program is greatly appreciated.

Sincerely,

A handwritten signature in cursive script, reading "Robert B. Lagather".

Robert B. Lagather
Assistant Secretary
for Mine Safety and Health

Enclosures

M 24

MEMORANDUM FOR: SECRETARY OF LABOR

FROM: ROBERT E. LAGATHER Signed Robert E. Lagather
Assistant Secretary
for Mine Safety and Health

SUBJECT: Department of Labor Involvement with the
National Storage Petroleum Reserve Program

The President has set a Strategic Petroleum Reserve (SPR) goal for the storage of one billion barrels of oil by 1983. The Department of Energy (DOE) has a current fill schedule of 125 million barrels in underground storage by the end of 1978. The Mine Safety and Health Administration understands that most of this oil will be stored in two mines, Weeks Island and Cote Blanche, which are in salt domes along the Louisiana Gulf Coast. The SPR program is based on active mining being continued in the domes, adjacent to, below and above the stored oil. Unfortunately, DOE has not advised MSHA of its future planning, and we do not know if other "dual-purpose" mines are being considered.

In early 1976, MSHA was advised of the possible utilization of mines for the strategic storage of petroleum. It was not until late 1976, however, that MSHA received a feasibility study from DOE, oriented to the economics of the oil storage program, for review and comment. Recognizing the potential hazards to any miners and mining activities in the vicinity of oil storage, MSHA had a multi-discipline Task Force investigate the technical feasibility of dual-purpose mines. They have met with DOE, its consultants and contractors, and the mine operators, from early 1977 to very recently, to discuss and review their proposed plans. Additionally, the Task Force investigated the Weeks Island and Cote Blanche mines, and the other three salt domes comprising the Five Island Mines. Information on the "blowout" phenomena, strata permeability, seepages of oil, gas and water and the mining operations was gathered. The interaction between the mining operations and the stored oil was then developed.

The Task Force investigation of the Five Islands Salt Mines has been completed. A copy of their report is attached for your information. Their conclusions and recommendations have been reviewed by MSHA's senior staff who concur with their findings.

Interdepartmental conflicts will arise from dual-purpose mines. However, it is in DOE's and the Nation's best interest to mine adjacent to the stored oil. For example, the Cote Blanche salt dome has at least 700 million tons of economically recoverable salt outside of the proposed oil-storage "envelope." That salt belongs to mineral-rights holders; we estimate royalties of \$300,000 per year (about 19¢/ton) and a full purchase price of at least \$80 million. The superior purity and color of that salt and its relatively low energy demand in processing make it desirable to textile, food processing, and chemical, among other industries. Its low cost to mine and its ready access to market make that salt more economically attractive than most other deposits in the country. Additionally, mine wages and taxes are critical to the local communities and the State.

Present DOE planning for the active mining and oil storage within the same dome has the potential for serious to disastrous health and safety hazards to the miners. In the MSHA report on the Five Island Mines, recommendations are included which will militate against those hazards. However, DOE, their consultants and the mine operators may be reluctant to consider our recommendations.

Should the present course of action be continued by DOE, we will have no recourse other than to issue withdrawal orders as mandated by Section 104 of Public Law 95-164, the Federal Mine Safety and Health Act of 1977. Such action can be expected to adversely affect the negotiations between DOE and the mine operators of sites being considered for the SPR program, as well as create other legal and social problems for the affected storage site and surrounding area. Additionally, the Task Force in their report identifies the problem of uncontrolled flows of water, which even with the absence of active mining, has the potential for destroying the integrity of an oil storage area. It is questionable whether DOE understands the implications related to uncontrolled waterflows.

The above briefly summarizes MSHA's involvement with DOE's oil storage program. I believe that the DOE continuing its present program in the manner planned would be an embarrassment to the Government. At your convenience, I would appreciate the opportunity of further discussion on this matter.

Attachments



MORTON SALT COMPANY
DIVISION OF MORTON-NORWICH

May 22, 1978

Mr. Monte Canfield, Jr.
Director
United States General Accounting Office
Energy and Minerals Division
Washington, D. C. 20548

Dear Mr. Canfield:

On April 28, 1978, we received your letter dated April 26 to John Kolbas enclosing for our comment sections of a draft report of potential problems with using certain salt caverns and mines under the Strategic Petroleum Reserve Program. We met with Ralph Calloway and Lucille Perholtz to discuss our comments at their request.

We are pleased that you provided us with the opportunity to comment on a matter that is of extreme importance to us, to our employees, and to the local community.

It may be best to begin with a little history as background. Morton and its predecessor in interest have been producing salt from Weeks Island since the turn of the century. Morton is the owner of Weeks Island, and carries on not only rock salt mining, but also solution mining, milling, processing, packaging and loading operations. Morton Chemical, another Division of Morton-Norwich Products, Inc., operates a chemical plant on the Island which uses salt produced at Weeks Island as feedstock, and is in the process of building a new, additional chemical plant at a cost of \$15,000,000.

DOE chose the Weeks Island rock salt mine as one of four sites for the Early Strategic Reserve. DOE advised Morton that it would acquire the mine based upon negotiated terms and conditions or, absent such, would take the mine by condemnation. Morton did not solicit this acquisition, and Morton was, in reality, a forced - and not a willing - seller. Negotiations with DOE were carried on, and consummated, based on the condition that DOE was acquiring only that property needed for oil storage; namely, the subterranean mine and appurtenances and easements. Morton would continue to own the surface buildings and facilities and the remainder of the salt dome from which it could continue to produce salt. The actual transfer of title to the property and payment of the \$30,000,000 consideration were by means of condemnation, instituted by the Department of Justice in the U. S. District Court in Lafayette, Louisiana.

We trust that you appreciate that these arrangements were undertaken for a multitude of reasons. Obviously, the cost to the Government was minimized

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by not taking all of Weeks Island, but rather taking only that deemed necessary by DOE. It also minimizes the disruption not only to the Company and the nearby communities, but also to the work force, to the local economy, including businesses and suppliers serving Weeks Island, to the up-river distribution system of Morton, and to the many hundreds of rock salt customers served by Weeks Island. Your report fails to adequately recognize these important benefits to be gained by Morton being able to continue to mine at Weeks Island.

In a portion of your draft report, you discuss what is titled: "Uncertain Effects of Continuing Mining Below the Oil Storage Area," and cite two problem areas, blowouts and boreholes. With reference to the blowout problem, we have several comments. First, we certainly agree that a safe distance between the oil storage area and the new mining area is vital. Our goal, as yours, is to identify "what is safe." We trust you appreciate that all mining operations, as most other things in life, are not absolutely free from any and all risk. Rather, the attempt has to be to identify what is safe to a reasonable degree of certainty and what is the nature and extent of the risk. We believe we have done this by analyzing the risk objectively and realistically, and by planning our new, permanent mining level at a depth of 370 feet beneath the oil storage. Only the sump area of the present production shaft (18 feet in diameter) will be as near as 300 feet.

We consider this sill thickness to be very safe based upon standard operating practices of Morton and the industry in general, and upon rock mechanic's considerations. The results of a finite element analysis performed at the University of Illinois confirms this view, which analysis is documented in a report by A. J. Hendron, Jr. entitled, "Preliminary Finite Element Study of Proposed Third Level Mine at Weeks Island with Oil Storage in Levels 1 and 2" dated May 23, 1977.

We question your factual basis for concluding that "a blowout could occur in Morton's working mine that might extend to the oil storage area above and flood the working mine with oil." Such would require a blowout of at least 370 feet, vertical dimension, which, as far as we know, is simply presumptive and conjectural. The largest blowout ever experienced at Weeks Island extended thirty feet long and ten feet in diameter, not the 100 feet referred to on Page 12 of your draft report. We suspect your reference to a reported 100-foot blowout was in connection with another salt dome. Please recognize that salt domes are different, with different characteristics.

With reference to your Page 12, first paragraph, world-wide experience indicates that various criteria are available for predicting areas with blowout potential, and your attention is directed to the following reference material: Proceedings of the 1966 Leipzig Conference on Sudden Outbursts. A study, recommended by MSHA, is being undertaken through Dames & Moore, consultants in earth sciences, to develop criteria to fit our local situation. The scope of this study is set forth in the attachment, with the intent being to complete the study by September, 1978.

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With reference to your Page 12, second paragraph, DOE is quoted as being of the opinion that "sufficient study had not been done to predict and control blowouts." We do not object to DOE or MSHA undertaking further studies to the extent either believes necessary. The study we are undertaking, referred to in the prior paragraph, could greatly ameliorate the concerns.

The reference in your report to the salt company being totally responsible for a blowout which would cause damage to the oil storage area is an erroneous assumption. Liability is a legal question that depends upon the various facts and circumstances. We would hope that DOE recognizes its responsibility to utilize the property it acquired by condemnation from Morton in a manner that does not cause damage to Morton, as the adjacent property owner, or does not otherwise deprive Morton of the use of its property.

In the final paragraph of Page 12, the statement attributed to MSHA about fractures and cracks is rather confusing. Only if a blowout occurred spontaneously at the floor of the oil storage can it be envisioned that fracturing would extend downward to the roof (free face) of the mine below. Even then, horizontal stress in the separating sill pillar would tend to seal the fracture. If the reverse were true; that is, a blowout occurrence in the roof of the new mine, all expelled salt would move out of the opening, and any cracks would parallel the remote end of the opening created, as evidenced by the blowouts in salt and potash mines throughout the world. It should be understood that the gas in a blowout is usually CO₂ and does not explode, but merely breaks through the thin wall created in its proximity by the advancing face.

You should recognize that the blowout-prone zones at Weeks Island have a pattern related to relict bedding planes in areas of metamorphism. These contorted planes are vertical in attitude, and their downward projection will simply be avoided in mining a lower level. Probe drilling will be carried out routinely in the new mine so that potential blowouts will be identified and bled off harmlessly.

It is also important that you recognize that mining directly below the present mined area offers the best opportunity for avoiding sudden blowout problems. The vertical attitude of the geology provides the basis for identifying potential blow-out zones in the new mine in that the new mine level below should be substantially a "carbon copy" of the existing mine, where we have identified the location of the blowout areas. We intend to avoid such areas in our future mining.

With reference to problems with boreholes on your Pages 13 and 14, we do have records of all boreholes, and none of the holes is deep enough to reach the new level. We intend to plug all of them with non-shrinking grout. Furthermore, we intend, as an additional safety precaution, to treat all

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holes as if they were improperly plugged and, even though properly plugged, we intend, in future mining beneath, to mine around them, leaving them in the center of a substantial pillar. Even if the implausible occurred, it would be entirely possible to insert a packer and valve into a vertical borehole in the mine roof under full-head-of-oil conditions. 1/

One final point needs to be made. References in your report to MSHA's opinions are not supported by the Agency's representations to us. We have, from the beginning, attempted to work closely with MESA, its predecessor, and have proceeded only after getting its approval in concept. We have not been advised that this concept is no longer acceptable or that it would present an imminent danger to our workforce.

We hope our comments are of assistance to you in understanding what is involved at Weeks Island. We, like you, are interested in the safe implementation of the Strategic Petroleum Reserve Program at Weeks Island. To the extent there exist unreasonable risks and unsafe conditions, we wish to be aware of them, and would be happy to work with DOE, MSHA, and/or GAO in solving them.

Please be sure to advise us if you would like any additional information. Again, we appreciate this opportunity to provide you with our comments.

Very truly yours,

MORTON SALT DIVISION
MORTON-NORWICH PRODUCTS, INC.

John M. Kolbas
President

JMK:nhm
Attachments

1/GAO note--The issue of boreholes is no longer addressed in this report because additional information we obtained led us to conclude that the boreholes had been located.

ATTACHMENT

Sudden Outburst Study:

1. Catalog location and size.
2. Gather samples of expelled salt, if possible.
3. Make physical and chemical comparison of expelled versus "normal" salt.
4. Sample wall rock of cavities for anomalous salt.
5. Probe-drill suspect zones, core and analyze.
6. Map geology in known zones.
7. Attempt gas analysis, expelled and "normal."
8. Measure gas pressure.
9. Observe sudden outburst cavities in other mines and comment.
10. Plot zones if identifiable on both mining levels.
11. Vertical (or slightly inclined, based on geology) drill holes in zones. Limited upward and downward depths.

1. On current mine map, plot location of all positively identified sudden outbursts. Indicate in a key the size of the outbursts referenced to their location number. Note trends so that probe drilling for others may be undertaken intelligently.
2. In some cases expelled salt may be still available for analysis and comparison to background "normal" salt. Decrepitation upon solution or heating, microscopic examination, petrofabric comparisons, etc.
3. See 2 above, also spectroscopic analysis for trace elements may be undertaken (expelled vs. normal).
4. If no expelled salt can be positively identified, perhaps wall rock of outburst cavities may prove anomalous.
5. Drilling and coring along identified trends may produce samples that can be "fingerprinted" so that future mining can utilize similar techniques. If possible, drilling should be done through a packer with a provision for catching a gas or fluid sample.
6. The mappable geology in outburst prone zones may be sufficiently unique to allow future prediction based on this parameter.
7. To the extent that gas samples can be collected, they should be analyzed for composition.
8. See 5 above; if packer can be closed in sufficiently quickly, gas pressures can be gauged.
9. Seek permission, through MESA, to observe similar phenomena in the four other Louisiana salt mines. Do not attempt in-depth study, but gather comments (and perhaps samples).
10. Map geology if possible in superposed position on upper level; if structure deviates from vertical, make proper allowance.
11. It would be highly desirable, if time permits, to drill vertically (or parallel to slightly inclined structure), both upward and downward, in known zones or exactly at the locus of an existing outburst. This has the best chance of proving or dispelling the theory that outburst zones parallel structure, and, therefore, are predictable on lower mining levels. Also, with luck, gas pressure variances (or similarities) may be observed.



Department of Energy
Washington, D.C. 20545

July 18, 1978

Mr. Monte Canfield, Jr., Director
Energy and Minerals Division
U. S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Canfield:

Thank you for the opportunity to review and comment on the GAO draft report entitled "Questionable Suitability Of Certain Salt Caverns And Mines For The Strategic Petroleum Reserve." Our views with respect to the text of the report and recommendations made by GAO are discussed below.

The GAO report addresses a number of geological and engineering aspects of petroleum storage in salt domes. It discusses some of the technical issues which the Department and its contractors have identified and considered during the technical evaluation and design of SPR sites.

We believe that GAO's concern over DOE's cavern certification program and the potential for caverns to grow together is unwarranted because:

- DOE's cavern certification program consists of more tests than the pressure tests referred to in the report. Directional surveys, sonar surveys and cement bond logs are an integral part of the certification program to assure the structural stability and integrity of all solution-mined caverns which have been certified.
- As the report points out, pressure tests conducted for the two caverns cited in GAO's report were performed at pressure 30 percent above the planned maximum operating pressure.
- Caverns currently planned for SPR oil storage have passed all certification tests and are satisfactory for at least one fill and withdrawal cycle. At no time has there been any evidence that certified caverns are not suitable for oil storage. DOE monitoring during oil fill operations shows that there has been no oil loss in any of the caverns currently being filled.

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- ° The possibility for caverns to coalesce after multiple withdrawals is real. The actual nature of cavern growth is difficult to predict and tests will be performed after each withdrawal to determine precisely the scope of cavern enlargement.
- ° If tests indicate that one or more caverns could coalesce after another fill and withdrawal, mitigating measures can be taken. For example, it is a common industry practice to use brine as a displacement fluid during withdrawal to prevent any future cavern growth.

DOE intends to develop plans for refill of the reserve in the event of a withdrawal which will include plans for abandoning or modifying the use of certain caverns if necessary. When such plans are developed, they will be furnished to the Congress.

Also, we will develop a formal system or procedure for documenting cavern test results including procedures for assuring appropriate approvals of any deviations from test criteria.

We do not agree with the conclusion that the Weeks Island storage site may not be suitable for oil storage.

- ° GAO's finding that all areas of the mine had different test results is inaccurate. The test results did not give an indication that the mine was not suitable for storage. All variances in measurements were within the sensitivity bands of the test equipment used.
- ° Areas selected as test locations within the mine were those which have the highest probability of failure during oil storage. Tests were performed in the lower level of the mine because the greatest pressures will result at this level. Salt characteristics are considered to be equivalent between the upper and lower levels of the mine.
- ° Close visual inspection of all portions of the mine was performed as part of the mine certification program. Furthermore, extensive mine conversion work being performed in both the upper and lower portions of the mine continues to confirm that the mine is totally suitable for oil storage.
- ° Technical analyses performed by DOE contractors indicate that 300 feet of salt is desirable beneath the oil storage to insure the integrity of the site. This evaluation was based on the structural nature of the mine and salt dome, the possibility of

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a mining operation below the storage area and the potential for blowouts. The question of web thickness was discussed with Mining Safety and Health Administration (MSHA) prior to acquiring the mine and no objections were raised by MSHA at that time about the 300 foot thickness. Accordingly, DOE's purchase of the mine included 300 feet of salt below the existing mine.

- Morton Salt Company's plans to mine below the storage area are contingent upon approval by MSHA. MSHA's concern that a mining operation below the oil storage could pose risks is based principally on the fact that little technical data and analysis is available on salt mine blowouts. If the planned MSHA study of blowouts indicates that the DOE property acquisition is insufficient, DOE will take all action necessary to insure site safety including acquisition of additional salt below the existing mine if necessary.
- Morton Salt Company is currently mining salt an area above and off to the side of DOE's property. Operations in this area are expected to continue through 1980 and do not jeopardize miner safety in any way. Morton is maintaining its salt production levels and DOE's acquisition of the mine has resulted in no unemployment or adverse economic impact.
- Water intrusion is a constant possibility in all salt mining operations. Modern mining techniques and practices are designed to avoid and control potential water problems. The Weeks Island mine has a 75-year record of safe operations. The water problem cited by GAO was encountered by Morton while excavating in a new area above and to the side of the oil storage area. Water inflow has been controlled and will continue to be monitored. The concrete bulkheads being installed in the mine by DOE to contain the stored oil would prevent any potential water inflow from reaching the oil storage area.
- GAO's comments on the outcome of Morton's plans to continue mining are highly speculative. Morton owns vast quantities of salt not only below the storage site but to all sides. The specter of unemployment, adverse financial impact, lack of miner safety and litigation are unwarranted at this time since MSHA is only beginning its evaluation process and Morton appears to have alternatives to mining below the oil storage area.

DOE cannot agree with GAC's recommendation to delay storage development and oil fill at the Weeks Island site. There is no evidence, facts, or

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test data to indicate that the mine is not suitable for oil storage. Morton's mining operations through 1980 pose no health or safety hazard to miners or the oil storage area. Furthermore, there is adequate time and alternatives exist so that the issue of where Morton can safely and economically continue to mine salt at Weeks Island can be resolved. Delaying the use of the site for strategic petroleum storage will not contribute to the resolution of this issue.

On the other hand, delaying oil storage at the site will increase this nation's vulnerability to interruptions of oil imports. It is necessary to weigh the risk of the economic and social loss which could result without this SPR site against the risk of some impact on future mining in the salt dome. In addition, the cost of delaying or terminating DOE contractors, which are currently converting the mine for oil storage and are constructing oil distribution facilities, would be high with little or no benefit derived.

The concerns raised by GAO are being resolved and pose no serious risk to the integrity of the storage system. DOE agrees with GAO that the SPR Program should be developed to minimize risk. However, we disagree with GAO that all uncertainties (no matter how minimal) should be or can be fully resolved before proceeding with SPR implementation. The risks cited by GAO are of little consequence when compared with reduced protection to the nation which would result from delays in program development. Further, it is impossible to eliminate all risks that may be associated with any type of oil storage.

Sincerely,



Fred L. Hiser, Director
Division of GAO Liaison
Office of the Controller

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